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Socioeconomic and health impacts among the elderly of their dwelling environment

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Introduction

The benefits of dwelling energy renovation have mostly been evaluated in terms of the resultant indoor environment parameters and the achieved reduction in the energy consumption. In the renovation design stage, simulations of these outcomes can be weighed against the costs incurred in implementing the renovation. It is more difficult to value consequences for well-being and health of the indoor environment improvement that may follow dwelling energy renovation (Howden-Chapman & Chapman, 2012). The reasons probably include lack of valid assessment methods and insufficient data to reliably estimate the socioeconomic value of the well-being and health effects of energy renovations.

Energy renovation and indoor environment

In temperate and cold climate zones such as e.g. Denmark, dwelling energy renovation typically includes increased insulation of the building envelope, new windows, sealing of the building envelope, ventilation with heat recovery, or replacing the dwelling heat source, if feasible (Witterseh et al., 2013). Each renovation measure may be connected with several aspects of the indoor environment, e.g. sealing the envelope will affect the dwelling outdoor air supply and thus the air quality, and the thermal conditions. Imagined associations between dwelling energy renovation and the outcomes for the occupants may be many and very complex as suggested in Figure 1.

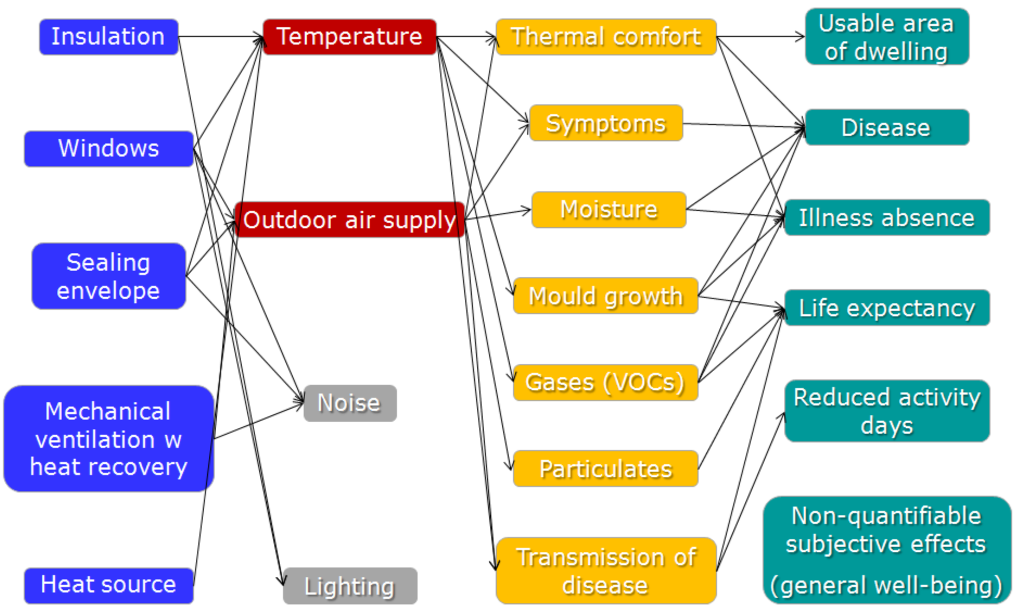

Figure 1. Each of the energy renovation measures (blue) affects the indoor climate (red/grey) via different mechanisms (yellow) and have different effects on the occupants.

Effects of energy renovation on occupant health and well-being

We spend on average 16 hours per day in our homes (Keiding et al., 2003) and the elderly probably even more. In addition, the elderly may be more vulnerable than the general population to indoor environment exposures. However, rather few studies are available that evaluate the effects of energy renovation on health and well-being among the elderly. An important factor is the household income, which for the elderly may be low and a reason for "fuel poverty", sometimes defined as those households employing more than 10% of the income on heating. These households will fail to keep their home adequately warm (Howden-Chapman & Chapman, 2012). Energy renovation will improve thermal comfort and general well-being in such homes. For example, a comprehensive project in New Zealand upgraded 47,000 homes and found a benefit-to-cost ratio of 4-to-1 by comparing the investment to savings on hospital admissions of the elderly and frail with respiratory or cardiovascular diseases (Grimes et al., 2011).

If not compensated for by an adequate ventilation retrofit, there is a risk that changes made to the building envelope will reduce the outdoor air supply to the dwelling, which may increase occupants' exposure to gaseous and particulate air pollution. Several studies have linked low air exchange rate with children's development of asthma and allergy (e.g. Bornehag, et al., 2005), respiratory infections (Nardell et al., 1991) and other respiratory and cardiovascular diseases (studies summarized in Chau et al., 2008). The consequences are many and include reduced activity days, working days lost due to own or child's illness, hospitalization or even death to the most vulnerable groups.

In dwellings, the transfer of viruses and bacteria via the air may not be the most important infection route. Nevertheless, there are indications that a lower ventilation rate results in a larger risk of exposure to airborne aerosols with infectious rhinovirus, which is responsible for between 30% and 50% of all respiratory infections incl. common cold (Dick et al., 1987; Jennings & Dick, 1987; Myatt et al., 2004; Sun et al., 2011). Several of the cited studies were conducted in dwellings known to have very high occupant density, such as military barracks and dormitories, and they are probably not fully representative of more common single-family dwellings.

The risk of infection due to airborne transmission of bacteria and viruses may be affected by humidity by several mechanisms. Air humidity impacts the viability of bacteria and viruses and the time the infectious aerosols spend in the air in the home. Over short distances, factors such as air distribution and air movement are important, while a larger distance between individuals may result in lower infection risk. By direct transfer (contact), temperature and humidity may affect the longevity of bacteria and viruses on surfaces. In particular, "damp buildings" have been associated with increased morbidity from respiratory infections and symptoms (Pirhonen et al., 1996).

The general increase in the prevalence of asthma and allergy has been attributed to reduced ventilation and increased humidity (Folkesundhed, 2007). Without adequate supply of outdoor air to an energy-renovated home there is a risk that sealing of the envelope can lead to an even lower air exchange than before the renovation. Bekö et al. (2010) measured the air exchange in 500 Danish homes and found that 56% of the homes had an air change rate lower than the 0.5 h^{-1}, which is required by the Danish building regulations. Bekö et al.'s study did not analyse separately homes that were renovated for increased energy efficiency.

Particles formed outside due to traffic, energy production or other industrial combustion processes or emissions from wood-burning stoves can be brought into the house by ventilation through windows and vents and through infiltration. Dose-response relationships have been determined between acute symptoms and cardiovascular diseases and outdoor particulate levels (Dockery & Pope, 1994; Pope & Dockery, 2006).

In their summary of available studies on indoor air pollution and health in the elderly, Bentayeb et al. (2013) found that a majority of the reviewed studies suggested a significant relationship between exposure to indoor air pollutants and short-term and long-term respiratory health endpoints such as wheezing, breathlessness, cough, and chronic obstructive pulmonary disease (COPD). However, they also concluded that further studies are needed to define causality. For exposure to ambient air pollution, a very recent and comprehensive multi-family study found increased risks of acute coronary events among the 60-74 year olds (Cesaroni et al., 2014).

Bräuner et al., (2008) found that particle concentrations indoors could be reduced by recirculation and filtration of the indoor air and lead to reduced risk of cardiovascular symptoms among an otherwise healthy population of elderly. However, a later study applying a similar method did not detect effects of particle filtration on microvascular and lung function (Karottki et al., 2013).

Summary

In general, the cited studies suggested complex and indirect relationships between socioeconomic and health benefits of increasing dwelling energy efficiency. Some associations have been found between dwelling indoor environment exposures and their effects on the elderly, but the effects vary between studies. There is a tendency that the available studies are strong on the epidemiology and effect outcomes (hospital admissions, doctoral visits, use of medication), but not so strong on the characterization of the exposure in the dwelling. Other studies are stronger on the exposure characterisation (particles, combustion gases, VOCs, thermal conditions) in few dwellings, which does not provide sufficient data for analysis of health effects (observational or intervention studies).

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